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Effects of two different grafts on radiological and functional outcomes in the surgical treatment of calcaneus fractures

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ABSTRACT

Aims: There are no standards regarding the use and selection of grafts for calcaneal fractures in the literature. This study aims to contribute to the literature by evaluating the effects of allografts and synthetic grafts on union and functional outcomes in the treatment of calcaneal fractures.

Methods: Intraarticular calcaneal fractures treated surgically between 2011 and 2018 with a minimum follow-up of 2 years were included in the study. Patients were divided into two groups based on the type of graft used: synthetic grafts (G45S5 bioactive glass, Noraker®) or allografts. The Böhler angle and Gissane angle were measured radiologically. Functional outcomes were assessed using the American Orthopaedic Foot & Ankle Society (AOFAS) Score and Maryland Foot Score at the final follow-up.

Results: The average age in the synthetic graft group was 37.5±12.4 years, while that of the allograft group was 37.8±8.6 years. Radiographic evaluations of both groups showed some degree of collapse in the posterior facet of the talocalcaneal joint in both postoperative and 2-year follow-up images. No significant differences were found between the groups in terms of the AOFAS Score or Maryland Foot Score at the 2-year postoperative evaluation.

Conclusion: There was no significant difference in functional and radiological outcomes between synthetic and allografts in the surgical treatment of calcaneal fractures.

Keywords: Calcaneus fracture, allograft, synthetic graft

INTRODUCTION

Calcaneus fractures are typically seen as a result of high-energy traumas such as falls from a height or motor vehicle accidents.[1] Between 60% and 75% of these fractures are intraarticular, with particular treatment challenges arising from the collapse and depression of the posterior facet of the talocalcaneal joint.[2,3]

Treatment goals for calcaneus fractures include the accurate anatomical restoration of displaced joints and the correction of the height, width, and length of the calcaneus for stable osteosynthesis. Surgical treatment of calcaneus fractures should also ensure the anatomical reconstruction of the foot's subtalar and calcaneocuboid joints.[4] In some cases, graft augmentation is used to support the facet in fractures with joint depression.[5]

In calcaneus fractures, when the underlying bone is crushed and the subtalar joint is depressed, reconstruction involving the elevation of the bone fragments leaves a gap that needs to be filled with a bone substitute, such as an autograft, allograft, xenograft, or synthetic prosthesis.[6] Autografts are obtained from the patients themselves and integrate better than allografts or xenografts. They aid in healing with their osteoinductive and osteogenic properties but also come with complications such as additional surgical procedures and donor-site comorbidities.[6]

Demineralized allografts are commonly used to fill voids. Allografts enhance bone healing in areas where healing is difficult, providing osteoinductive properties and mechanical support when necessary.[6]

The primary advantages of xenografts are their lower cost and easier availability,[7] although they have greater antigenicity compared to allografts. Data on bone xenografts in humans is limited. Bovine-based xenografts are considered to offer structural integrity and ease of use in reconstructive foot surgeries.[6] β-Tricalcium phosphate (β-TCP) ceramics, on the other hand, have been reported to exhibit rapid in vivo biological degradation.[8]

In this study, we aimed to contribute to the literature regarding graft selection in the treatment of calcaneus fractures, as there are no standards for graft usage in these cases. We also aimed

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to evaluate the effects of allografts and synthetic grafts on union and functional outcomes in calcaneus fractures.

METHODS

The study was carried out with the permission of Ethical Committe of Ankara Bilkent City Hospital (Date: 28.04.2021, Decision No: 21-1704). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki. Between 2011 and 2018, 67 patients with intra-articular calcaneus fractures were operated on. Among these 67 patients, 5 had fractures in the contralateral extremity, and 3 developed wound infections during postoperative follow-up. Therefore, a total of 59 patients were included in the study. These 59 patients were retrospectively analyzed.The inclusion criteria were being over 18 years of age, having undergone surgery for closed fractures, patients who received grafts and being followed up for at least two years. Patients with open fractures, those who did not receive grafts, and those with other fractures in the same or contralateral lower extremity were excluded from the study. In the surgical treatment, synthetic G45S5 bioactive glass (Noraker®, Lyon, France) or an allograft was used. Patients were divided into two groups based on the type of graft used: synthetic grafts or allografts. Preoperative, early postoperative, and final follow-up radiographs, including ankle, anteroposterior, lateral, and axial views, were obtained for all patients. The Bohler and Gissane angles were measured radiologically. The Sanders classification was applied based on preoperative computed tomography scans and only patients with Sanders type 3-4 fractures were included in the analysis. Posterior facet collapse was evaluated by interpreting the Bohler and Gissane angles on the X-ray. The American Orthopaedic Foot & Ankle Society (AOFAS) Score and Maryland Foot Score at the final follow-up were used to evaluate functional outcomes.

Surgical Technique

Patients were positioned laterally on a radiolucent table with a tourniquet applied to the upper thigh. A lateral L-shaped extended incision was made. A subperiosteal flap was created, preserving the surrounding soft tissue and the sural nerve. After clearly visualizing the fracture line, the lateral wall fragments were lifted from the calcaneus like a shell, exposing the depressed posterior facet. By placing an osteotome or using periosteal stripping as leverage, the depressed fragment was elevated to its normal superior position. Temporary fixation of the posterior facet was achieved by passing Kirschner wires from the talar portion to the sustentaculum. Reduction of the posterior facet, calcaneocuboid joint, anterior process, and sustentaculum as well as varus/valgus alignment were checked using fluoroscopy with lateral, Harris axial, and serial Broden views. At this stage, bone defects were observed in the area where the posterior facet was elevated, and based on the surgeon's preference, a synthetic graft or allograft was tightly placed into the calcaneus. In both groups, after reduction, permanent fixation was performed using an anatomical calcaneal plate with low-profile, locking, and headless screws. A final fluoroscopic control was conducted and all Kirschner wires were removed. The wound was closed using subcutaneous absorbable 2-0 sutures and a subcutaneous drain was placed. The skin was closed with non-absorbable 3-0 sutures. A dressing was applied, followed by thick cotton wool padding and a short leg splint.

Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics 22.0 for Windows. Descriptive statistics were expressed as frequency, percentage, mean, standard deviation, median, and minimum-maximum values. Since the Shapiro–Wilk test indicated non-normal distribution for the quantitative variables, non-parametric tests were used. The Mann-Whitney U test and Wilcoxon test were employed to determine the relationships between parameters. The chi-square test was used for categorical data analysis. Results were evaluated with a 95% confidence interval and $p<0.05$ was considered significant.

RESULTS

The mean age was 37.5±12.4 years in the synthetic graft group and 37.8±8.6 years in the allograft group (Table 1). There was no significant difference between the two groups in terms of preoperative Bohler and Gissane angles. Comparing the postoperative and 2-year Bohler and Gissane angles, no significant difference was found between the groups. Posterior facet collapse of the talocalcaneal joint was observed in both groups when comparing postoperative to 2-year radiographs. In the allograft group, posterior facet collapse was detected in 13 patients, while in the synthetic graft group, it was found in 10 patients.Functional outcomes as evaluated at the 2-year follow-up with the AOFAS Score and Maryland Foot Score also revealed no significant difference between the groups. Early wound infections were observed in one patient in the synthetic graft group and two patients in the allograft group (Table 2).

Table 1. Demographic characteristics

Characteristic	Synthetic graft (n=27)	Allograft (n=32)	p
Sex, female/male	8/19	10/22	
Age, years, mean	37.5±12.4	37.8±8.6	0.653

Table 2. Clinical and radiological characteristics

Measurement	Gissane angle (°)			Böhler angle (°)		
	Synthetic graft (n=27)	Allograft (n=32)	p	Synthetic graft (n=27)	Allograft(n=32)	p
Preoperatively, mean±standard deviation	145.6±20.5	138.9±21.3	0.080	12.7±10.3	12±15.8	0.749
Postoperatively, mean±standard deviation	130.6±12.4	127.1±12.7	0.273	29.3±5.8	27.7±8.6	0.189
Two-year follow-up, mean ± standard deviation	132±13	128.3±13.3	0.266	28.1±6.1	26.2±9.8	0.111
	AOFAS Score			Maryland Foot Score		
	Synthetic graft (n=27)	Allograft(n=32)		Synthetic graft (n=27)	Allograft (n=32)	
	82.3±4.7	82.5±5.6	0.963	52.3±3.6	52.5±4.4	0.837

DISCUSSION

This study compared the effects of synthetic grafts and allografts on radiological and functional outcomes in the surgical treatment of calcaneus fractures. The results showed that both types of grafts significantly improved the patients' postoperative Bohler and Gissane angles. However, posterior facet collapse of the talocalcaneal joint was observed in both groups during the 2-year follow-up, consistent with previous studies on calcaneus fractures. The literature reports that posterior facet collapse is a common problem following surgery for calcaneus fractures.[4]

Analyses of functional outcomes using the AOFAS Score and Maryland Foot Score revealed no significant differences between the synthetic and allograft groups. These findings suggest that both graft types provide successful outcomes in the surgical treatment of calcaneus fractures without functional superiority of one over the other. The significant advantages of synthetic grafts include their cost-effectiveness and availability.[6] These advantages, in addition to the rapid biological degradation and supportive bone-healing properties of synthetic grafts, may make them preferable.[9]

Other studies in the literature have generally examined the effects of a single graft type, with limited studies comparing different grafts. This study provides information to guide clinical practice by directly comparing both graft types. Recent systematic reviews and meta-analyses have also shown that synthetic grafts yield long-term results similar to those of allografts. Autografts in particular are thought to accelerate the healing process due to their osteoinductive and osteogenic properties. However, the extent to which these advantages are reflected in clinical outcomes remains unclear. In some previous studies, patients who received autografts showed slightly faster union compared to synthetic grafts, but this did not create a significant difference in long-term follow-up.[9,10] These findings align with those obtained in the present study and suggest that synthetic grafts can serve as a viable alternative to autografts. β-TCP-based synthetic materials have been particularly widely discussed in the literature due to their rapid biological degradation and supportive bone-healing effects.[8]

Some researchers have suggested that the use of synthetic grafts accelerates bone healing but does not achieve the same long-term level of osteointegration as allografts.[7] However, in this study, synthetic grafts and allografts provided similar functional results over a 2-year follow-up period. While allografts are generally considered superior due to their osteoinductive and osteogenic properties,[6] our study found that those advantages did not result in a clinically significant difference.

The infection findings of this study are also notable. Early wound infections were observed in one patient in the synthetic graft group and two patients in the allograft group. The lack of a significant difference in infection rates between the two graft types suggests that graft selection is not a decisive factor in infection risk. Although the literature suggests that allografts may offer some advantages in terms of infection risk,[7] our findings do not support that theory. Other studies in the literature have similarly reported that infection rates do not vary significantly based on graft type.[12] Further studies with larger patient populations are needed to achieve more meaningful results regarding wound infection rates.

We believe that improving the biocompatibility of synthetic grafts and minimizing infection risk may be essential points of focus for future research. The impact of graft usage on bone union is also an important finding. No significant difference was observed between the groups in terms of union times after surgeries. Although the literature suggests that the osteoinductive properties of allografts may accelerate union,[6] synthetic grafts have been shown to support bone healing successfully.[8] This finding suggests that synthetic grafts may be a suitable treatment option, especially when cost and accessibility are prioritized.

This study offers clinicians different options in terms of cost-effectiveness and accessibility regarding graft selection and suggests that synthetic grafts can be considered as an alternative according to other studies in the literature.

Limitations

Due to this study's single-centre and retrospective nature, it is not possible to rule out potential factors that may have influenced our findings. Other limiting factors of the study include the lack of long-term results for a control group without grafts.

CONCLUSION

No significant differences were found between synthetic grafts and allografts regarding functional and radiological outcomes in the surgical treatment of calcaneus fractures. This suggests that synthetic grafts can serve as viable alternatives to allografts, particularly in terms of cost-effectiveness. However, the occurrence of posterior facet collapse with both graft types underscores the importance of closely monitoring long-term outcomes in the treatment of these fractures. Furthermore, future studies with longer follow-up periods and larger patient populations are needed to compare different graft materials. Such studies will provide clearer insight into the impact of graft selection on fracture healing.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was carried out with the permission of Ethical Committe of Ankara Bilkent City Hospital (Date: 28.04.2021, Decision No: 21-1704).

Informed Consent

Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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